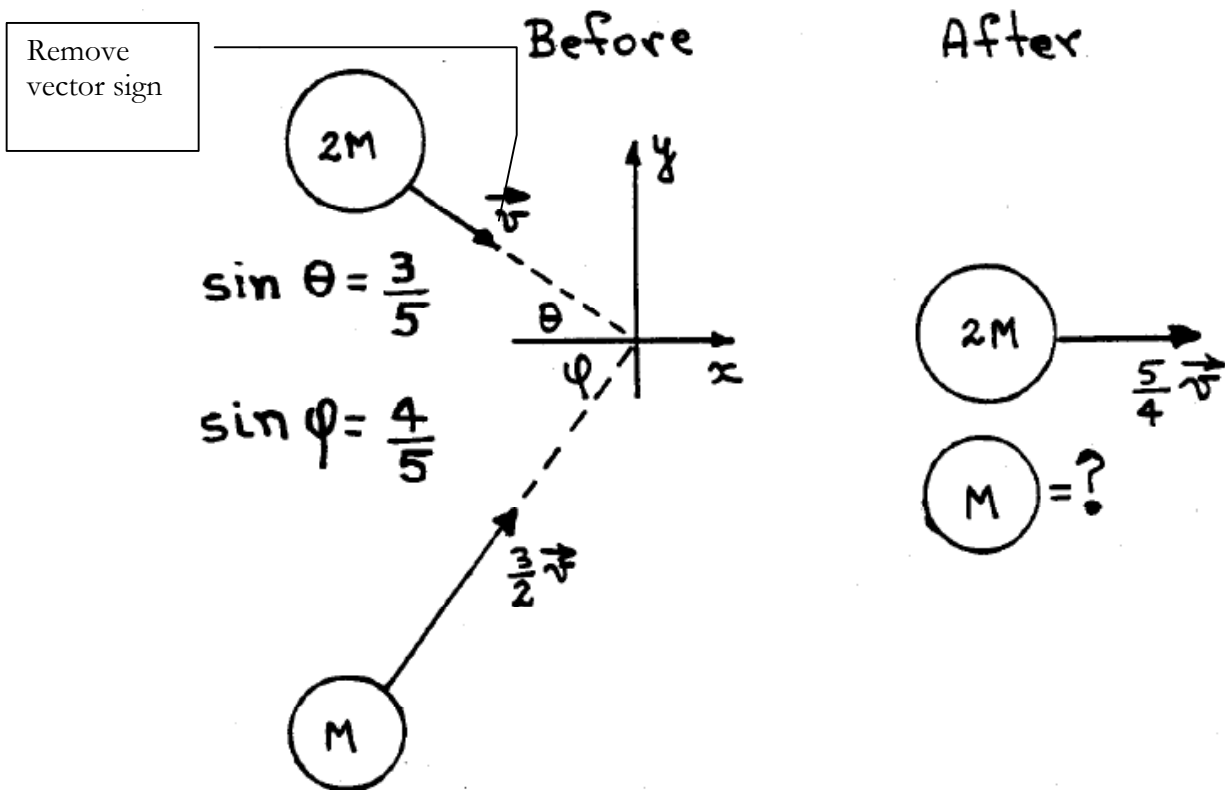


Name: \_\_\_\_\_

Problem 1: Collision (15 Points)

Two objects move on a collision path as shown. Before the collision the object with mass  $2M$  moves with a speed  $v$  making an angle  $\theta$  to the x-axis.  $\sin \theta = \frac{3}{5}$ . The object with mass  $M$  moves with a speed  $\frac{3}{2}v$  making an angle  $\phi$  with the x-axis.  $\sin \phi = \frac{4}{5}$ . After the collision the mass  $2M$  is observed to be moving to the right along the x-axis with a speed of  $\frac{5}{4}v$ . There are no external forces acting during the collision. In your solution you must justify any assumptions you make about the nature of the collision (**elastic or inelastic**). State all answers in terms of  $M$  and  $v$ .

- What is the linear momentum  $\mathbf{P}$  of the system before the collision? State your answer in terms of its two components  $P_x$  and  $P_y$ .
- What is the velocity of the mass  $M$  after the collision? State your answer in terms of its velocity components  $v_{x\text{-}}$  and  $v_{y\text{-}}$ .
- What is the velocity  $v_{\text{cm}}$  of the center-of-mass of the system before the collision? What is it after the collision?



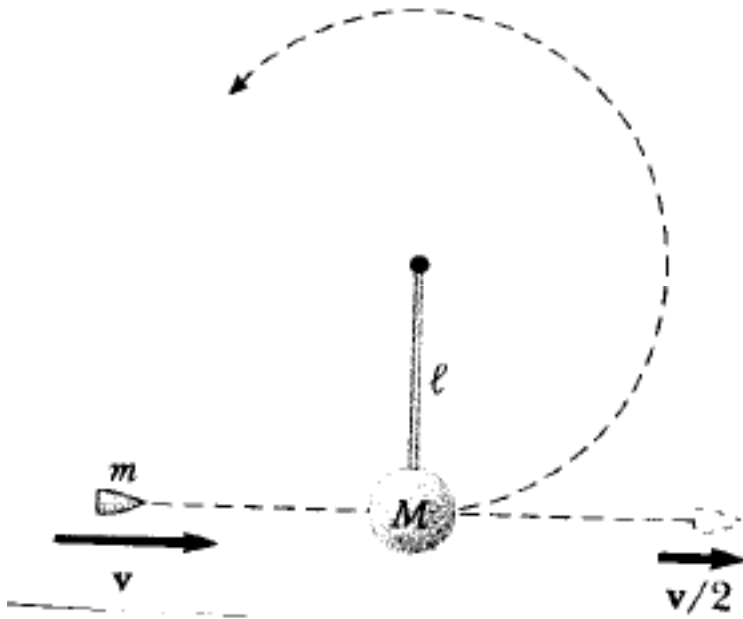
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Problem 2: Colliding Bullet (15 Points)

A bullet of mass  $m$  and speed  $v$  passes completely through a pendulum bob of mass  $M$ . The bullet emerges after the collision with a speed of  $v/2$ . The pendulum bob is suspended from a stiff rod of length  $l$  and negligible mass. State all answers in terms of  $m$ ,  $M$ ,  $v$ ,  $g$ , and  $l$ .

- What is the speed of the pendulum bob immediately following the collision?
- What is the minimum value of  $v$  such that the pendulum bob will barely swing through a complete vertical circle?
- What is the tension  $T$  in the rod (magnitude and direction) when the bob reaches the top of its swing for the minimum  $v$ ?
- What is the acceleration  $\mathbf{a}$  of the bob at the top of the swing for the minimum  $v$ ?



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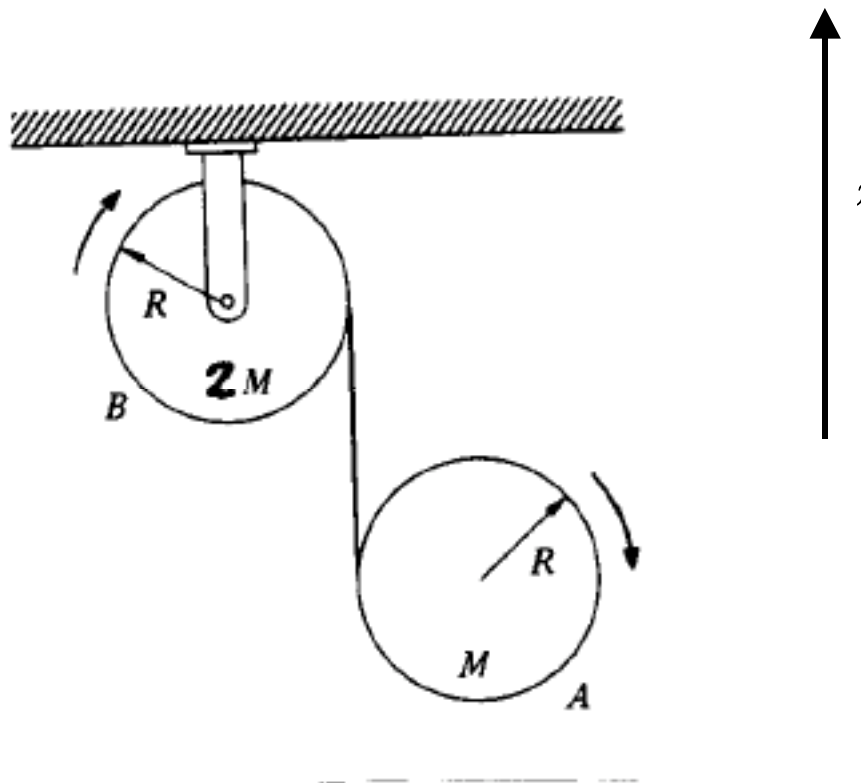
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Problem 3: Rotational Dynamics (15 Points)

Two pulleys are connected by a thin rope whose mass can be neglected. The top pulley has a mass  $2M$  and the lower pulley a mass  $M$ . Both are solid cylinders of radius  $R$ . The top pulley is fixed in space but can rotate freely. The bottom pulley can rotate and fall under gravity. Give all your answers in terms of  $M$ ,  $R$ , and  $g$ .

- What is the relationship between the angular accelerations  $\alpha_1$  of the top pulley,  $\alpha_2$  of the bottom pulley and a the linear acceleration of the bottom pulley?
- What is the tension  $T$  in the rope?
- What is the acceleration  $a$  of the lower pulley?
- What are  $\alpha_1$  and  $\alpha_2$ ?

You need to make clear there is a coil of rope around each

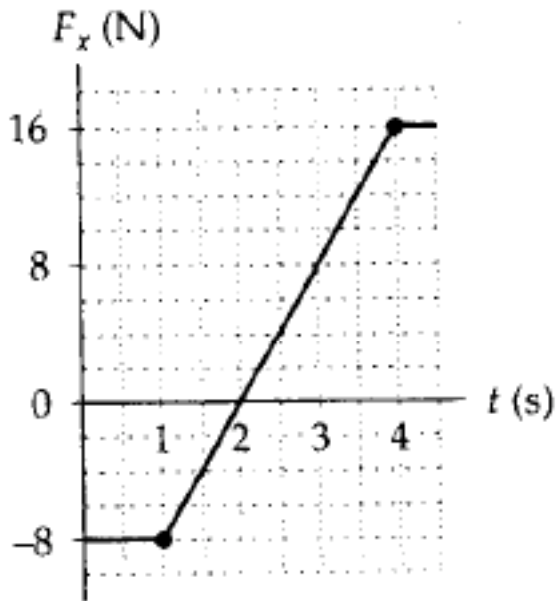


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Problem 4: Multiple Choice (15 Points)

Circle the correct answer for parts 1, 2, 3, 4 and 5. If no answer is correct, do NOT circle any part and write "None of the above" clearly on your paper.

1. The only force acting on a 2.0-kg object moving along the x-axis is shown. If the velocity  $v_x$  is +2.0 m/s at  $t=0$ , what is the velocity at  $t=4.0$  s?



- a. +4.0 m/s
- b. +5.0 m/s
- c. +6.0 m/s
- d. +7.0 m/s
- e. +2.0 m/s

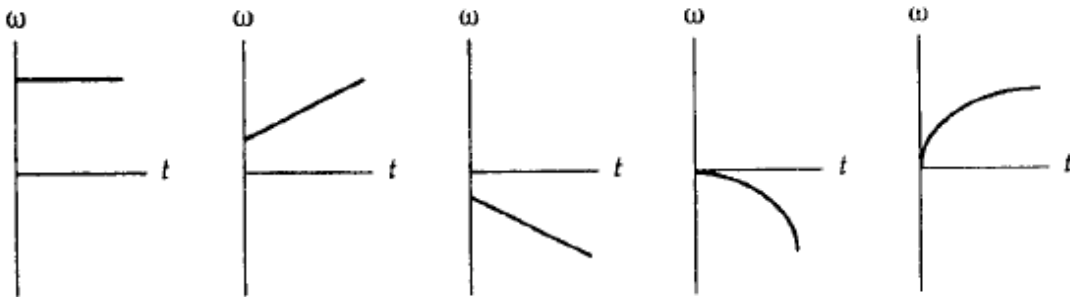
2. When two bodies of different masses collide, the impulses they exert on each other are:

- a. equal for all collisions
- b. equal but opposite for all collisions
- c. equal but opposite only for elastic collisions
- d. equal but opposite only for inelastic collisions
- e. equal but opposite only when the bodies have equal but opposite accelerations

3. Two cars start at the same point, but travel in opposite directions on a circular path of radius  $R$ , each at speed  $v$ . While each car travels a distance less than  $(\pi/2)R$ , one quarter circle, the center of mass of the two cars

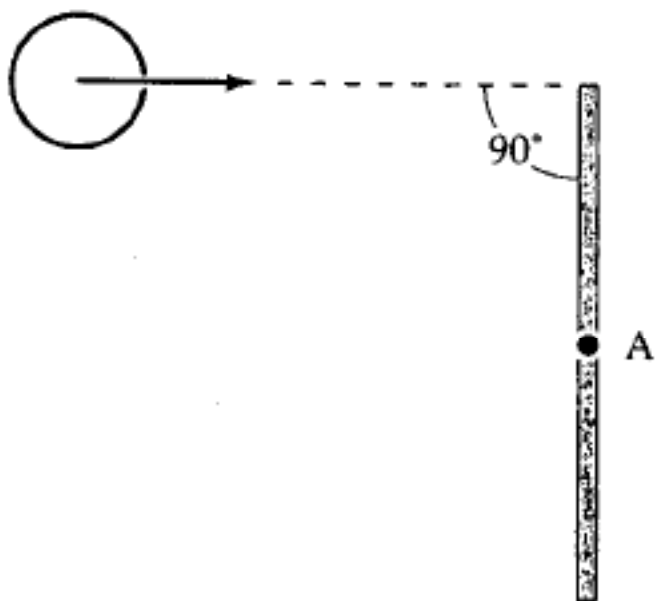
- a. remains at the initial point
- b. travels along a diameter of the circle at speed  $v_c < v$
- c. travels along a diameter of the circle at speed  $v_c = v$
- d. travels along a diameter of the circle at speed  $v_c > v$
- e. remains at the center of the circle

4. The graphs below show angular velocity as a function of time. In which one is the magnitude of the angular acceleration constantly decreasing?



- a.   b.   c.   d.   e.

5. A thin rod of mass  $M$  and length  $L$  is struck at one end by a ball of clay of mass  $m$ , moving with speed  $v$  as shown in the figure. The ball sticks to the rod. After the collision, the angular momentum of the clay-rod system about  $A$ , the midpoint of the rod, is



- a.  $(m+M/3)(vL/2)$
- b.  $(m+M/12)(vL/2)$
- c.  $(m+M/6)(vL/2)$
- d.  $mvL/2$
- e.  $mvL$

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